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Longitudinal Observation of Developmental Change in Maxillary Deciduous and Permanent Canines

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Abstract

During the period of the growth and development of the dental arch, anterior-posterior and medial-lateral changes in the maxillary deciduous and permanent canines were longitudinally studied in children. A longitudinal series of dental casts were obtained from 50 children at 2-month intervals from the completion of deciduous dentition to the stable period of permanent dentition. Subjects were divided into two groups according to the arrangement of the permanent teeth: a normal dental arch group and a crowded dental arch group. The mesial and distal points of the deciduous and permanent canines and the most prominent points on the labial and lingual contours were observed longitudinally. The results indicated that the measurement points of the deciduous canines in the normal and crowded groups moved in the anterior and lateral direction. When the amount of movement in the normal group was compared to that in the crowded group, the normal group showed greater movement than the crowded group. The permanent canines in both groups moved in the anterior and medial directions. When the amount of movement in the normal group was compared to that in the crowded group, the normal group showed more anterior movement than the crowded group, and the crowded group showed more medial movement than the normal group. When the distal point of the permanent canine was compared with the point of the deciduous canine at the exfoliation period in the normal arch group, the permanent canine was in almost the same position or was in a more anterior position than the deciduous canine. In the crowded arch group, the permanent canine tended to drift posteriorly.

Key words: Canine—Developmental changes—Longitudinal observation—Same children—Leeway space

Introduction

The deciduous and permanent canines are located where the anterior teeth transition to the posterior teeth in the dental arch. Because of this, they influence the positions and arrangement of both the anterior and posterior teeth during the developmental
phase of dentition and thus play a critical role in determining the eventual condition of the dental arch and occlusion at the completion of permanent dentition.

Several reports on positional change of the deciduous canines and permanent canines have been published. However, most of these studies only examined relative positional changes based on changes in the length and width of the dental arch, and only a few employed direct observation of the occlusal aspect to determine actual movement within the dental arch. Nanba et al. investigated positional change of the canines from the occlusal aspect. However, their study only included children with normal dental arches observed over a very short period from the time of gingival emergence of the canines to the time when the crowns fully erupted.

Burdi and Moyers noted that the deciduous canines moved distally or some of the leeway was used up as the incisors erupted to replace the predecessor teeth while the incisors aligned in the mandibular dentition; no mention was made of the maxillary dentition, however.

In this study, dental casts collected from children every 2 months from 3 years of age to the stable period of permanent dentition were used to examine positional change in the maxillary deciduous and permanent canines from the occlusal aspect during growth and development. Children with normal dental arches and children with crowded dental arches were included in order to reveal any differences in positional change.

Material and Methods

1. Study materials

Fifty Japanese children were included in the study. Dental casts were collected at 2-month intervals from the completion of deciduous dentition to the stable period of permanent dentition in order to obtain study materials in a longitudinal series of dental casts. All children in the study had normal occlusion of the deciduous dentition. The children lost no deciduous or permanent teeth due to injury or caries and showed no abnormal oral habits during the study period. Children who developed caries on any tooth influencing the measurements were excluded. Informed consent was obtained from the parents or guardians prior to material collection. The children were divided into two groups according to the arrangement of permanent teeth: a normal dental arch group (30 children, 15 boys and 15 girls) and a crowded dental arch group (20 children, 10 boys and 10 girls). A crowded dental arch is a condition where the teeth are misaligned and tend to overlap one another in certain regions.

2. Study methods

1) Standardization of models

The reference plane was defined as the maxillary cast from 3 points of the center point of incisive papilla and the lowest points of the lingual cervical line of the right and left second deciduous molars. The models were standardized so that the cast basal surface was parallel to the reference plane, and the distance between the cast basal surface and the reference plane was identical. Kubodera et al. reported that the position of the lowest point of the lingual cervical line of the maxillary second deciduous molar started to change 4 months before shedding. Therefore, the reference points were changed from the lowest point of the lingual cervical line of each second deciduous molar to that of each first permanent molar 6 months before either of the second deciduous molar was shed.

2) Measurement methods

An image of each standardized cast was captured in the direction perpendicular to the reference surface by the Multipurpose Image Processor (MIP), and the image files of the occlusal views were included. Based on the files, the outlines of each tooth and rugae were traced to create drawings. Reference points and measurement points were plotted on the traced drawings and measured by the MIP.

Eight months after gingival emergence of the canines, when rapid positional and axial
change due to eruption of the canine crown has finished, was considered the time of complete eruption of the canine crown. The coordinates on the X- and Y-axes for each measurement point at that time were set to 0 as the origin to calculate distance. The distance calculation and statistical analysis were performed using a personal computer.

(1) Determination of reference lines and measurement points

The X-Y-axes were defined as the position of each of the measurement points as coordinates to longitudinally investigate the anteroposterior and mediolateral positional change in the deciduous and permanent canines. The midline, a line defined by the center point of the incisive papilla and the distinct point in the posterior region of the medial palatine raphe, was defined as the Y-axis. The X-axis was defined as the line drawn through the endpoint of the left second palatine raphe perpendicular to the Y-axis. Four points, the most medial and distal points and the most prominent points on the labial and lingual contours of the deciduous and permanent canines were chosen as the measurement points (Fig. 1).

(2) Observation methods

a. Average position change

Dental age with reference to the time of gingival emergence of the permanent canines was used to determine average positional change in the deciduous and permanent teeth. The observation period for the deciduous canines was from 6 years before gingival emergence of the permanent canines, which corresponded to the time of completion of deciduous dentition (Stage 1), to shedding (Stage 2). Permanent canines were observed from the period of gingival emergence (Stage 3) to 8 years after emergence when stable permanent dentition was acquired (Stage 4).

All subjects were divided into either normal or crowded dental arch groups and the two groups compared. The average age at gingival emergence of the permanent canines was 10 years 10 months (± 1 year 2 months SD) in the normal dental arch group and 10 years 9 months (± 10 months SD) in the crowded dental arch group.

b. Positional change in individual subjects

As the same change would not be observed in all subjects, average positional change could not explain individual change in all subjects. Therefore, all subjects were classified into three types to examine individual change in each subject according to the positional relationship between the most distal point of the deciduous teeth at just before shedding (4 months before gingival emergence of the permanent canines) and the most distal point of the permanent canines in the stable period of permanent dentition:

Type I: The most distal point of the canines in the stable period of permanent dentition was located more than 1 mm anterior to the corresponding point of the deciduous canines just before shedding.

Type II: Anteroposterior change in position was less than 1 mm and approximated average positional change. Type II were further classified according to antero-posterior movement; children with anterior and posterior movement were represented as ( + ) and ( - ), respectively.

Type III: The most distal point of the canines in the stable period of permanent dentition was located more than 1 mm posterior to the corresponding point of the deciduous canines just before shedding.

3) Statistical analysis

Welch’s t-test was used to determine the
significance in differences between groups.

Results

No significant differences were found in the measurements obtained between males and females or between the right and left sides. Therefore, the subjects were not classified by sex but divided into a normal dental arch group of 30 subjects (60 sides) and a crowded dental arch group of 20 subjects (40
Table 2  Amount and direction of movement integrated in medio-lateral and anteroposterior direction at each measurement point in both groups

<table>
<thead>
<tr>
<th>Period of observation</th>
<th>Distal point</th>
<th>Mesial point</th>
<th>Labial point</th>
<th>Lingual point</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal</td>
<td>Crowding</td>
<td>Normal</td>
<td>Crowding</td>
</tr>
<tr>
<td>Deciduous canine</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stage 1 to 2</td>
<td>Distance</td>
<td>2.03</td>
<td>1.76</td>
<td>2.16</td>
</tr>
<tr>
<td></td>
<td>Direction</td>
<td>Anterior</td>
<td>Anterior</td>
<td>Anterior</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and lateral</td>
<td>and lateral</td>
<td>and lateral</td>
</tr>
<tr>
<td></td>
<td>Angle (°)</td>
<td>62.8</td>
<td>66.7</td>
<td>66.9</td>
</tr>
<tr>
<td>Canine</td>
<td>Stage 3 to 4</td>
<td>Distance</td>
<td>0.92</td>
<td>1.18</td>
</tr>
<tr>
<td></td>
<td>Direction</td>
<td>Anterior</td>
<td>Anterior</td>
<td>Anterior</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and medial</td>
<td>and medial</td>
<td>and medial</td>
</tr>
<tr>
<td></td>
<td>Angle (°)</td>
<td>18.4</td>
<td>83.7</td>
<td>13.7</td>
</tr>
<tr>
<td>Stage 2 to 4</td>
<td>Distance</td>
<td>1.63</td>
<td>0.67</td>
<td>2.67</td>
</tr>
<tr>
<td></td>
<td>Direction</td>
<td>Anterior</td>
<td>Anterior</td>
<td>Anterior</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and lateral</td>
<td>and lateral</td>
<td>and lateral</td>
</tr>
<tr>
<td></td>
<td>Angle (°)</td>
<td>26.3</td>
<td>48.0</td>
<td>2.4</td>
</tr>
</tbody>
</table>

Midline was defined as 0 for angle. (mm)
*p<0.05, **p<0.01

sides) for the statistical analysis.

1. **Average positional change**

The average positional change of each measurement point during each observation period in the normal and crowded dental arch groups is shown in Table 1.

1) Positional change in deciduous canines (From Stage 1 to Stage 2)

Each measurement point in both groups showed medial and lateral movement during the period from the completion of deciduous dentition to the shedding of the deciduous canines. However, except for anterior movement of the most prominent point of the lingual contour, greater change was observed in the normal dental arch group than in the crowded dental arch group.

2) Positional change in permanent canines (From Stage 3 to Stage 4)

The measurement points of the permanent canines, except the most prominent point of the lingual contour, which moved in the posterior direction, showed a tendency to move anteriorly and medially. The amount of anterior movement in the normal dental arch group was greater than that in the crowded dental arch group. Thus, the normal dental arch group showed a stronger tendency toward movement in the anterior direction, whereas the crowded dental arch group showed a greater amount of medial movement.

3) Relative position of deciduous canines and permanent canines (From Stage 2 to Stage 4)

Each measurement point of the deciduous canines just before shedding and the permanent canines in the stable period of permanent dentition was compared and anterior movement observed in both groups. When movement in the mediolateral direction was observed, the most prominent points of the labial contours and the most medial points of the canines seldom moved in the normal dental arch group, whereas in the crowded dental arch group, the most prominent points of the lingual contours moved in the mediolateral direction. All other measurement points moved in the lateral direction.

The amount and direction of movement in both the deciduous canines and permanent canines is shown in Table 2. The schematic in Fig. 2 uses superimposition to reveal positional change in the anteroposterior and mediolateral directions based on the data obtained. The arrows show changes in the coordinate value of each measurement point for each observation period in the normal and crowded dental arch groups. The results show that the canines moved more anteriorly
and less medially in the normal dental arch group, whereas in crowded dental arch group, they moved more medially than anteriorly.

2. Change in individual subjects

Tables 3 and 4 show the results of classification according to difference in position between the most distal point of the deciduous teeth just before shedding and the permanent canines at the time of final observation. Type II subjects were further classified by antero-posterior movement, and children with anterior and posterior movement were represented as (+) and (−), respectively.

A total of 66.7% of the normal dental arch group was classified into Type I or showed anterior movement of more than 1 mm. No subjects in the normal group were classified into Type III, and 6.6% of the normal group was categorized as Type II (−). The total percentage of subjects classified into Type III and Type II (−) was not less than 25.0% in the crowded group. More specifically, more subjects in the crowded dental arch group showed distal movement of the canines compared to the normal group. In addition, amount of posterior movement was as small as 0.17 mm in the normal dental arch group, whereas in the crowded group, relatively greater movement of 0.48 mm for Type II (−) and 1.58 mm for Type III was observed.

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**Table 3** Rate of each type categorized by relative position between most distal point of deciduous teeth just before shedding and that of permanent teeth during stable period of permanent dentition

<table>
<thead>
<tr>
<th>Type of group</th>
<th>Type of dentition</th>
<th>Normal</th>
<th>Crowding</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td></td>
<td>44 (66.7)</td>
<td>17 (42.5)</td>
</tr>
<tr>
<td>II (+)</td>
<td></td>
<td>16 (26.7)</td>
<td>13 (32.5)</td>
</tr>
<tr>
<td>II (−)</td>
<td></td>
<td>4 (6.6)</td>
<td>6 (15.0)</td>
</tr>
<tr>
<td>III</td>
<td></td>
<td>0</td>
<td>4 (10.0)</td>
</tr>
</tbody>
</table>

(%)
Discussion

1. Study methods

Most previous studies on the growth and development of the dentition focusing on change in deciduous and permanent canines only examined and reported change in intercanine width and length of the dental arch. This measurement is simply a relative estimation of positional change in the canine region based on change in width and length. Most of these studies chose a single point for measurement of the deciduous or permanent canines.

Nanba et al.\(^\text{14}\) reported that the permanent canines emerged through the gingiva at about 27 degrees to the midline and that 4 months later the inclination increased to about 31 degrees, decreasing again to about 28 degrees at the time of full eruption of the crowns. Such complicated positional change in the canines cannot be examined simply by observing a single measurement point as was done in previous studies. Therefore, in this study, the four most medial and distal points and the most prominent labial and lingual contour points were selected and their coordinates used to calculate distance. The equipment used in this study had an integrated precision of 0.03 mm, which was considered appropriate for the objectives of the study. Thus, close observation was possible of positional change in the deciduous and permanent canines during growth and development.

2. Average change

All previous studies examined the inter-canine width of the deciduous canines in normal dentition\(^\text{1–6,11–13,15–19}\), and the increased intercanine width of the deciduous canines during growth and development of the dentition was reported. However, the results of this study suggest that width was not simply increased, but that the canines moved in the anterior and lateral directions as the dentition grew.

Additionally, all previous studies on the inter-canine width of permanent canines\(^\text{1–9,11–13,15–19}\) have reported a slight decrease in intercanine width with growth of the dentition. The results of this study indicated that the canines moved in the anterior direction and slightly in the medial direction during the period from completion of crown eruption to the stable period of permanent dentition in subjects with normal dentition. Meanwhile, the canines in subjects with crowded dental arches moved in the medial direction, but not in the anterior direction. This suggests that intercanine width in the crowded dentition group decreased significantly compared to that in the normal dental arch group.

Sillman\(^\text{16}\) reported an increase in inter-canine width between the ages of 2 and 12 based on data from birth to the age of 25. Similarly, Sakuma et al.\(^\text{15}\) studied intercanine width using a series of dental casts of children from the ages of 6 to 12 to reveal an approximately 5 mm increase in maxillary intercanine width during this period. In these studies, uniform increases in intercanine widths were suggested, even though the primary deciduous canines were replaced with permanent canines during the observation period. There-

<table>
<thead>
<tr>
<th>Type of group</th>
<th>Normal</th>
<th></th>
<th></th>
<th></th>
<th>Crowding</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of cases</td>
<td>Means</td>
<td>Max</td>
<td>Min</td>
<td>S.D.</td>
<td>Number of cases</td>
<td>Means</td>
<td>Max</td>
</tr>
<tr>
<td>I</td>
<td>40</td>
<td>2.05</td>
<td>3.69</td>
<td>1.09</td>
<td>0.68</td>
<td>17</td>
<td>1.70</td>
<td>2.73</td>
</tr>
<tr>
<td>II</td>
<td>16</td>
<td>0.52</td>
<td>0.99</td>
<td>0.03</td>
<td>0.31</td>
<td>13</td>
<td>0.34</td>
<td>0.90</td>
</tr>
<tr>
<td>III</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
<td>−1.58</td>
<td>−1.07</td>
</tr>
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Positive and negative values in table represent anterior and posterior movement, respectively.
fore, in this study, measurement points were compared between the deciduous canines at the time of shedding and the permanent canines during the stable period of permanent dentition.

In this study, a comparison of change in the position of each measurement point in the deciduous and permanent canines revealed some degree of difference in the medio-distal and labiolingual dimensions of the crowns between the deciduous and permanent canines. However, taking the average value of the permanent canines during the stable period of permanent dentition into consideration, there was clear anterior and lateral positioning of the permanent canines compared to that of the deciduous canines in both the normal and crowded dental arch groups.

3. Change in Individual Subjects

Observation of each of subject revealed different patterns of movement in the deciduous and permanent canines as opposed to uniform movement. Such movement cannot be understood by the simple observation of average change. Therefore, all subjects were classified into three types according to difference in the position between the most distal point of the deciduous teeth just before shedding and the most distal point of the permanent canines during the stable period of permanent dentition to examine the individual change in each subject.

Movement of the permanent canines distal to the position of the deciduous canines was observed in only 6.6% of the normal dental arch group, and no subjects showed distal movement of 1 mm or greater. In 93% of the subjects, the permanent canines were positioned more medially to the deciduous canines, and leeway in the maxillary arch should have been about 1 mm. In this study, however, the most distal points of the permanent canines were located at about 1.5 mm anteriorly to the deciduous canines on average. Therefore, the current results strongly suggest that, in patients who develop normal dentition during the stable period of permanent dentition, use of leeway is not the mechanism underlying normal alignment of the maxillary incisors.

Conversely, 10% of the crowded dental arch group showed movement of 1 mm or more of the permanent canines distal to the deciduous teeth, and about 75% of the subjects had more anteriorly positioned permanent canines than deciduous teeth. Hasegawa et al. reported that 9 subjects out of 13 subjects with negative leeway space in the maxillary arch developed a normal dental arch at the time of permanent dentition. In this study, the most distal points of the canines in the crowded group were found to be located 0.45 mm anteriorly to the deciduous canines on average. This may support previous findings that some subjects with negative leeway space can still develop a normal dental arch. However, compared to subjects with normal dental arches, children with crowded dental arches tend to have more medially shifted permanent canines than deciduous canines, which results in the recurrence of crowding in the anterior regions. In subjects showing distal movement of the canines, no resolution of the negative arrangement was observed, and crowding remained. Thus, an association is suggested between amount of medial movement of the canines and the development of crowded dental arches.

Conclusion

Our results showed that when the distal point of the permanent canines was compared with the point of the deciduous canines at the exfoliation period in the normal arch group, the permanent canine was in almost the same position or there was in a more anterior position than the deciduous canine. Posterior drift of the permanent canines was sometimes observed in the crowded arch group.

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